Laboratory Modeling Guidelines using ASHRAE 90.1-2004 Appendix G

DRAFT

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Carl Ian Graham	Steven Winter Associates
Itzhak Maor	PWI-Energy
Paul Mathew	Lawrence Berkeley National Laboratory
Susan Reilly	Enermodal Engineering, Inc.
Michael Rosenberg	Oregon Energy Office
Fred Porter	Architectural Energy Corporation
Otto VanGeet	National Renewable Energy Laboratory
Michael Walsh	R.G. Vanderweil Engineers, Inc.

Please direct questions and comments to:

Otto van Geet, National Renewable Energy Laboratory
email: Otto_VanGeet@nrel.gov ; voice: 303.384.7369

Laboratory Modeling Guidelines using ASHRAE 90.1-2004 Appendix G
DRAFT in DEVELOPMENT

Introduction

The following is a draft guideline for energy modeling of laboratory spaces in a building in accordance with ASHRAE 90.1-2004 Energy Standard for Buildings Except Low-Rise Residential Buildings, Appendix G. The provisions of this guideline are limited to systems serving laboratory spaces. As per OSHA 1910-1450, "Laboratory means a facility where the 'laboratory use of hazardous chemicals' occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis. Laboratory scale means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. 'Laboratory scale' excludes those workplaces whose function is to produce commercial quantities of materials."

The guideline directly references the ASHRAE 90.1-2004 standard. Only those sections of the standard being clarified or modified are discussed in the guideline; all other sections of the standard should be followed as defined in the standard.

This guideline addresses three areas pertaining to the use of Appendix G of the standard, each of which affects several sections of the standard, as shown below:

Guideline Area	**ASHRAE 90.1 sections being modified**
I. Baseline HVAC system type and energy recovery	6.5.7.2 Fume Hoods G3.1.1 Baseline HVAC System Type and Description Table G3.1.1A Baseline HVAC System Types G3.1.2.10 Exhaust Air Energy Recovery
II. Laboratory fan power limitation	6.5.3.1 Fan Power Limitation G3.1.2.9 Fan Power
III. Modeling load diversity and reheat energy impacts	Table G3.1 No.4 Schedules G3.1.3.16 (new) Supply-Air-to-Room Air Temperature Difference

For energy efficiency measures that are not explicitly addressed by the standard, we recommend application of Section G.2.5, Exceptional Calculation Methods. This guideline does not cover the details of such calculation methods.

The modifications to the sections of the standard are indicated through <u>additions</u> (underscore) and ~~deletions~~ (strikethrough).

I. Baseline HVAC System Type and Energy Recovery

6.5.7.2 ~~Fume Hoods~~ Laboratories

~~Buildings~~ Systems with ~~fume hood systems having a total exhaust rate greater than 15,000 cfm~~ 100% outside air design supply flow rates of 5,000 cfm or greater and laboratory exhaust systems, shall include at least one of the following features:

> a) Variable Air Volume ~~hood~~ exhaust and room supply system capable of reducing exhaust and make-up air volume to individual space by at least 50% or less of design values.
> b) Direct makeup air supply equal to at least 75% of the exhaust rate, heated no warmer than 2 F below room set point, cooled to no lower than 3F above room set point, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
> c) Energy recovery systems to precondition makeup air from ~~fume hood~~ laboratory exhaust in accordance with 6.5.6.1 (Exhaust Air Energy Recovery) without using any exception.

Rationale:
The requirements of 6.5.7.2 should apply to all laboratory systems, not just fume hoods. Laboratories may have many other types of exhaust devices such as ventilated enclosures, laminar flow hoods, snorkels, etc.

Making section 6.5.7.2 apply to all laboratory systems will clarify 90.1.
Labeling 6.5.7.2 "laboratories" instead of fume hoods would make the terminology consistent with Section 6.5.6.1 Exception (a) "Laboratory systems meeting 6.5.7.2".

Changing the flow rate to 5000 CFM from 15,000 CFM would make section 6.5.7.2 consistent with section 6.5.6.1, currently it is unclear what is required between 5000 and 15,000 CFM.

Labs21 has conducted a study analyzing the effects of efficiency measures such as VAV and energy recovery in several locations. The study concluded that VAV makes economic sense for all types of laboratory buildings in all locations and energy recovery makes economic sense in most locations see
http://www.labs21century.gov/pdf/cs_energyanalysis_508.pdf

Exceptions to G3.1.1

(d) Systems serving laboratories should conform with the requirements of System 5,6,7, or 8, depending on building area and heat source.

Rationale:
Table G3.1.1A as currently written for Building Type "Nonresidential & 3 floor or less & <75,000 ft2" defines a baseline of System ("PSZ-AC") or System 4 ("PSZ-HP"), both of which have packaged single-zone constant volume fan control. This is inappropriate and unrealistic for systems serving laboratory spaces. Many laboratory buildings would fit under this description as currently written.

Table G3.1.1A

Notes:
As indicated in exception (d) to G3.1.1, systems serving laboratories should conform with the requirements of System 5,6,7, or 8, depending on building area and heat source.

Rationale:
This additional note to the table simply reiterates the language in exception (d) of G3.1.1

Exceptions to G3.1.2.10

(h) Systems with 100% outside air design supply flow rates of 5,000 cfm or greater and laboratory exhaust systems, shall include at least one of the following features:

1) If the Proposed Building laboratory system includes Variable Air Volume meeting the requirements of Section 6.5.7.2(a), the Baseline System should be a Variable Air Volume exhaust and room supply system capable of reducing exhaust and make-up air volume to individual space by at least 50% of design values. Exhaust Air Energy Recovery should not be included.

2) If the Proposed Building laboratory system includes Exhaust Air Energy Recovery meeting the requirements of Section 6.5.7.2(c), the Baseline System should include Exhaust Air Energy Recovery meeting the requirements of this section without any exception. Variable Air Volume exhaust and room supply should not be included.

3) If the Proposed Building laboratory system includes both Variable Air Volume meeting the requirements of Section 6.5.7.2(a) and Exhaust Air Energy Recovery meeting the requirements of Section 6.5.7.2(c), the Baseline System should include Variable Air Volume exhaust and room supply system capable of reducing exhaust and make-up air volume to individual space by at least 50% of design values. Exhaust Air Energy Recovery should not be included.

Rationale:
This additional exception makes section G.3.1.2.10 consistent with section 6.5.6.1

II. Laboratory Fan Power Limitation

6.5.3.1 Fan Power Limitation

(d) For systems serving laboratories, use the fan power limitations in the following table:

Fan Power Limitations for Laboratory Applications

Supply Air Volume	Allowable Nameplate Motor Power	
	Constant Volume	Variable Volume
<20,000 cfm	2.2 hp/1000 cfm	3.1 hp/1000 cfm
>20,000 cfm	2.0 hp/1000 cfm	2.8 hp/1000 cfm

These fan power limitations are based on a combined static pressure ratio of 9.15" w.g. for supply and exhaust. Appendix A of this guideline lists the components included in this limit. The fan power may be adjusted for those components not listed in Appendix A. Any adjustment must be identical in the baseline and proposed designs.

Rationale: While the standard provides pressure credits for filtering systems, heat recovery, etc., laboratory fan systems typically exceed the fan limitations even with these credits, due to other components. Appendix A of this guideline lists the pressure drops of each component, comparing laboratory applications to typical commercial applications.

Exception to G3.1.2.9 Fan Power

For systems serving laboratories, use the fan power limitations in accordance with section 6.5.3.1 (d) as described in this guideline.

Rationale: See rationale for 6.5.3.1

III. Modeling Load Diversity and Reheat Energy Impacts

Table G.3.1 No.4. Schedules

Accurately model the equipment load in each laboratory space instead of using an average across all spaces. Appendix B of this guideline includes sample schedules that may be used for equipment, lighting, occupancy, and fumehoods. Alternatively, schedules based on observed load patterns could be used.

Rationale: It is important to consider the variation of internal equipment loads from one space to the next. This variation can have a substantial impact on energy use, especially reheat energy. To capture this effect, and reward designs that reduce reheat, equipment load variation should be modeled. Note that the variation should be modeled identically in the baseline and proposed designs.

HVAC fans will remain on during occupied and unoccupied hours in pressure controlled laboratory spaces that have health and safety mandated minimum ventilation requirements during unoccupied hours.

Rationale: Health and safety mandated minimum ventilation requirements preclude cycling fans, even during unoccupied hours.

G3.1.3.16 Budget Supply-Air-to-Room Air Temperature Difference

For systems serving laboratory spaces, use a supply-air-to-room-air temperature difference of 17 deg F.

Rationale: The usual supply-air-to-room-air temperature difference in commercial applications is 20 deg F. However, the minimum airflow rates in typical commercial buildings are much lower than those required in laboratory occupancies. The higher minimum airflow rates warrant a smaller temperature difference, to avoid excessive reheat.

Labs21 Modeling Guidelines APPENDIX A

The following table A1 is intended to provide guidance for establishing a “budget” fan horsepower limit for laboratory buildings. The intent is to allow users to establish a fan energy limit more appropriate for research facilities than the limits listed in ASHRAE 90.1, which are primarily intended for commercial buildings (i.e. offices, retail). Since with fixed design airflow the operating fan horsepower is directly proportional to the operating fan pressures, the table identifies typical pressure losses that would be used to determine a budget fan horsepower.

For comparison purposes, the table includes a column containing a list of typical components found in a commercial variable air volume duct system. No specific information on how the ASHRAE fan energy budget was established is included in the 2004 edition of the standard, so the list was established to determine typical components that would result in a fan horsepower similar to the limit listed in ASHRAE. Review of the original ASHRAE 90.1-1989 edition identified that for a budget built up central station VAV system, the static pressures used to determine the fan horsepower limits was 4” w.g. on the supply and 1” w.g. on the return (see ASHRAE 90.1-1989, page 114, System type 5). These values and the component values are not intended as recommended design criteria, but only as an example of components that may have gone into the ASHRAE fan energy budget. The laboratory column then identifies how these systems differ from the commercial system listed. The laboratory static pressure requirements were then used to establish the fan energy limit for the budget building systems listed in the modeling guide.

Since programmatic requirements may vary, components that may be required but are not considered typical have been provided in a second table A2. Where appropriate, the static pressure loss of these or other additional components necessary for the project are to be added to the total budget static pressure listed and a new fan power limit established for the budget building. The pressure losses used would be the same in both the baseline and proposed cases systems (thus raising the baseline by the same value as the proposed). This was done to ensure where components are necessary to meet local codes or standards, such as system intake sound levels, the addition of a component (i.e. intake sound attenuator) can be addressed by these guidelines. The establishment of a more appropriate baseline will also allow for credit when low duct pressure drop systems or component are included (i.e. low pressure drop coils).

TABLE A1 - System Static Pressure Allowance – Budget Laboratory Building					
Component	**Commercial Application Budget**	**Laboratory Application Budget**	**Difference**	**Criteria for Selection/Sizing**	**Comments**
			Supply System		
Intake Louvers	0.15" w.g.	0.15" w.g.		2001 ASHRAE Fundamentals, Chapter 34, Figure 15 and SMACNA Duct Design Table 9-8. Pressure drop is maximum typical value.	Based on 400 fpm over gross louver area, 800 fpm over net lover area. Design recommendation based on limiting water intake.
Intake Damper	0.07" w.g.	0.07" w.g.		1500 fpm – pressure drop from ASHRAE DFDB @ 1500 fpm	Typical design practice for selection of control dampers.
Prefilter	0.32" w.g.	0.32" w.g.		500 fpm – Clean pressure drop listed from manufacturer data, typical 24"x24" filter (Farr 30/30)	Filter Velocity: 2001 ASHRAE Fundamentals states duct velocity for low efficiency extended-surface. Typical AHU casing velocity = 500 fpm. Also see SMACNA Duct Design Table 9-8 Filter Type: 2000 ASHRAE Equipment, Chapter 24, Table 2 25% to 40% Dust Sport Efficiency Filters
Final Filter	N/A	0.55" w.g.	0.55" w.g.	500 fpm – Clean pressure drop from manufacturers data, typical 24"x24" filter (Farr Riga-flow 100)	Filter Velocity: 2001 ASHRAE Fundamentals states up to 750 fpm, but in practice, typically matches prefilter velocity. Also see SMACNA Duct Design Table 9-8. Filter Type: ASHRAE 2000 Equipment, Chapter 24, Table 2 - 80% - 85% extended surface bag or cartridge filter.
Preheat Coil - Steam	0.18" w.g. per ASHRAE DFDB at 800 fpm 1-row coil	0.38" w.g. per ASHRAE DFDB at 800 fpm 2-row coil	0.20" w.g.	800 fpm	2000 ASHRAE Equipment Chapter 24 states 200 to 1500 fpm. Must review part load operation. 800 fpm selected will allow VAV airflow reduction to 40% (or 320 fpm) while remaining within the ARI 410 rating range of 200 fpm to 1500 fpm. 800 fpm is found by experience to prevent excessive coil capacity and maintain proper airside temperature control. Tube velocities in smaller coils are also higher allowing setback while maintaining control.

TABLE A1 - System Static Pressure Allowance – Budget Laboratory Building					
Component	**Commercial Application Budget**	**Laboratory Application Budget**	**Difference**	**Criteria for Selection/Sizing**	**Comments**
Humidifier	0.00” w.g.	0.06” w.g.	0.06” w.g.	With 100% outside air in drier climates, a humidifier is required to meet ASHRAE Standard 55 for minimum humidity levels. Pressure drop from mfr. data (Dri-Steem Ultrasorb with 3” tube spacing @ 800 fpm)	Select to match velocity of upstream or downstream component. Allow space for air to transition. Use SMACNA transition angles to determine spacing.
Cooling Coil	0.75” – Sample selection for typical office occupancy 25% OA (Aerofin)	1.3” - Sample selection for typical lab occupancy 100% OA (Aerofin)	0.55”wc	500 fpm	2000 ASHRAE Equipment Chapter 24 states 200 to 800 fpm. Must review part load operation. 500 fpm selected will allow VAV airflow reduction to 40% (or 200 fpm) while remaining within the ARI 410 rating range of 200 fpm to 800 fpm. 500 fpm is found by experience to provide reasonable balance between pressure drop, cost and space
Unit Discharge Damper	0.13” w.g. per ASHRAE DFDB @ 2000 fpm	0.13” w.g. per ASHRAE DFDB @ 2000 fpm		1500 fpm.	Typical design practice for selection of control dampers. Smoke damper where applicable.
Ductwork AHU to Terminal Box < 6000 cfm	1.28” w.g. including fittings	1.28” w.g. including fittings		0.25” w.g. pressure drop per 100 ft	Allowance to match ASHRAE total. Typical loss per 100 ft, no guidelines from ASHRAE or SMACNA
Ductwork AHU to Terminal Box >/= 6000 cfm				2000 fpm	1991 ASHRAE Practical Guide to Noise and Vibration Control (velocity) and 2003 ASHRAE Applications. Based on typical standard radius elbows and a room NC=45. NC 45 selected ad mid range of research labs.
Ductwork Terminal Box to Space < 6000 cfm	0.1” w.g. including fittings	0.1” w.g. including fittings		0.10” w.g. pressure drop per 100 ft	Typical practice, no guidelines from ASHRAE or SMACNA
Ductwork Terminal Box to Space >/= 6000 cfm				2000 fpm	1991 ASHRAE Practical Guide to Noise and Vibration Control (velocity) and 2003 ASHRAE Applications. Based on typical standard radius elbows and a room NC=45. NC 45 selected at mid range of research labs.

TABLE A1 - System Static Pressure Allowance – Budget Laboratory Building

Component	Commercial Application Budget	Laboratory Application Budget	Difference	Criteria for Selection/Sizing	Comments
Fire Dampers	0.03” w.g.	0.03” w.g.		C=0.12 - Pressure drop from ASHRAE DFDB @ 2000 fpm	ASHRAE Duct Fitting Database
Terminal Box – Supply without Reheat Coil	0.94” w.g. total per ASHRAE DFDB @ 2000 fpm inlet velocity – includes 0.42” w.g. for HW coil	0.6” valve only	0.38” w.g.		ASHRAE data for commercial. Manufacturer data for laboratories. Based on Phoenix Controls venturi valve.
Duct Mounted Reheat Coil		0.42” w.g. (same as commercial)			Velocity to match low pressure duct system See criteria above.
Terminal Box Sound Attenuators		0.3” w.g. – estimate			Velocity to match low pressure duct system See criteria above.
Diffusers Registers and Grilles	0.05 “ w.g. per 1981 SMACNA duct design for square diffuser	0.10” w.g. – manufacturer data for radial pattern diffuser (Titus Tri-Tec)	0.05” w.g.	500 fpm	Based on velocity and selection at 5 NC below design conditions per recommendation from acoustical consultant. NC 45 selected at mid range of research labs.
Total Supply	4.0” w.g. Commercial	5.79” w.g. Laboratory	1.79”w.g. Difference		
Exhaust					
Registers and Grilles	0.20” w.g. per 1981 SMACNA duct design Table 9-7.	Use fume hood	0.55” w.g.	600 fpm	Based on velocity and selection at 5 NC below design conditions per recommendation from acoustical consultant. NC 45 selected at mid range of research labs.
Fume Hoods	N/A	0.75”wc		0.75” w.g.	Typical maximum hood loss per ANSI/AIHA Z9.5-2003 page 55.
Ductwork Terminal Box to Exhaust Fan < 6000 cfm	0.38” w.g.	1.28”wc – Use same as supply VAV duct allowance	0.9” w.g.	0.25” w.g. pressure drop per 100 ft	Allowance for commercial to match ASHRAE total. For labs, use same as supply duct allowance. Typical loss per 100 ft , no guidelines from ASHRAE or SMACNA
Ductwork Terminal Box to Exhaust Fan >/= 6000 cfm				2000 fpm	1991 ASHRAE Practical Guide to Noise and Vibration Control (velocity) and 2003 ASHRAE Applications. Based on typical standard radius elbows and a room NC=45. NC 45 selected ad mid range for typical research labs.
Ductwork Space to Terminal Box < 6000 cfm	0.10” w.g.	0.1” w.g.		0.10” w.g. pressure drop per 100 ft	Typical practice, no guidelines from ASHRAE or SMACNA

TABLE A1 - System Static Pressure Allowance – Budget Laboratory Building					
Component	**Commercial Application Budget**	**Laboratory Application Budget**	**Difference**	**Criteria for Selection/Sizing**	**Comments**
Ductwork Space to Terminal Box >/= 6000 cfm				2000 fpm	1991 ASHRAE Practical Guide to Noise and Vibration Control (velocity) and 2003 ASHRAE Applications. Based on typical standard radius elbows and a room NC=45. NC 45 selected ad mid range for typical research labs.
Terminal Box – Exhaust	0.0" w.g.	0.6" w.g.	0.6" w.g.	0.6"w.g.	Manufacturers design data Based on Phoenix Controls venturi valve.
Intake Damper	0.07" w.g.	0.07" w.g.		1500 fpm – pressure drop from ASHRAE DFDB @ 1500 fpm	Typical design practice for selection of control dampers.
Exhaust Discharge Stack	N/A	0.56"wc	0.31" w.g.	3000 fpm	3000 fpm from ANSI/AIHA Z9.5-2003 page 48. Pressure loss from ASHRAE Duct Fitting Database Co=1.0
Exhaust Louver – toilet and general exhaust systems only	0.25" w.g.	N/A		0.25" w.g.	2001 ASHRAE Fundamentals, Chapter 34, Figure 15 and SMACNA Duct Design Table 9-8 Based on 400 fpm over gross louver area, 800 fpm over net lover area.
Total Exhaust	1" w.g. Commercial	3.36" w.g. Laboratory	2.36" w.g. Difference		
Total System – Supply + Exhaust	**5" w.g. Commercial**	**9.15" w.g. Laboratory**	**4.15"w.g. Difference**		

TABLE A2- Examples of Additional Components to be added to Static Pressure Allowance Where Appropriate					
Component	**Commercial Application Budget**	**Laboratory Application Budget**	**Difference**	**Criteria for Selection/Sizing**	**Comments**
				Supply System	
Snow Melt Screen/Coil				Project Specific	Select for minimum pressure drop. Where applicable. Needed in some locations to prevent buildup of light snow on filters and associated inefficiency, added maintenance and additional pressure drop.
AHU Intake Sound Attenuator		0.03" w.g. per ASHRAE DFDB @ 500 fpm		500 fpm Select to match velocity of upstream or downstream component. Allow space for air to transition. Use SMACNA transition angles to determine spacing.	May be required to meet local ambient noise levels.
Preheat Coil – Hot Water & Glycol				500 fpm	Typical practice. If a hot water coil is used remove the pressure drop for the stream preheat coil
AHU Discharge Sound Attenuator		0.68" w.g. per ASHRAE DFDB @ 2000 fpm		Project Specific	Size to match supply duct. See velocity criteria above.
				Exhaust System	
Biosafety Cabinets – Class II Type A2				0.1" w.g.	Manufacturers design data.
Biosafety Cabinets – Class II Type B2				3" w.g.	Manufacturers design data.
Terminal Box Sound Attenuators				Project Specific	Velocity to match low pressure duct system See criteria above.
HEPA Filters					Required for Biocontainment Laboratories – Project Specific.

Labs21 Modeling Guidelines APPENDIX B

The schedules are based on ASHRAE 90.1-1989 for office occupancy except as noted (laboratories classified as office in ASHRAE 90.1). The schedules assume heavier loads during more typical working hours, 8am-5pm. Fans are assumed to be on 24 hours throughout the day. If the laboratory operates on a seasonal schedule, such as a school schedule, and has lower usage during one season adjust the schedules as needed.

Lab Occupancy Schedule

Starting Month: January Starting Daytype: Monday	Ending Month: December Ending Daytype: Friday
Period: Start - End (Hour)	% Diversity
0 - 7	5 (see note)
7 - 8	10
8 - 9	20
9 - 11	90
11 - 13	45
13 - 18	90
18 - 19	30
19 - 22	10
22 - 24	5 (see note)

Starting Month: January Starting Daytype: Saturday, Sunday	Ending Month: December Ending Daytype: Holiday
Period: Start – End (Hour)	% Diversity
0 - 7	5 (see note)
7- 9	10
9 -13	30
13 - 18	10
18 - 24	5 (see note)

Note: Minimal occupancy added to reflect laboratory operation.

Lab Lighting Schedule

Starting Month: January Starting Daytype: Monday	Ending Month: December Ending Daytype: Friday
Period: Start - End (Hour)	% Diversity
0 - 6	20(see note)
6 - 7	30(see note)
7 - 8	50(see note)
8 - 12	90
12 - 13	80
13 - 17	90
17 - 18	90
18 - 20	50
20 - 22	30(see note)
22 - 24	20 (see note)

Starting Month: January Starting Daytype: Saturday, Sunday	Ending Month: December Ending Daytype: Holiday
Period: Start – End (Hour)	% Diversity
0 - 6	10 (see note)
6 - 8	10 (see note)
8 -12	40 (see note)
12 - 17	20 (see note)
17 - 24	10 (see note)

Note: Lighting loads added to reflect 24-hour laboratory operation.

Lab Equipment Schedule
The schedules for internal equipment loads have been modified from the ASHRAE 90.1-89 equipment schedules that are identical to the lighting schedules. These schedules are based on default equipment schedules for labs used in eQuest software.

Lab Equipment Load Schedule – Typical

Starting Month: January Starting Daytype: Monday	Ending Month: December Ending Daytype: Friday
Period: Start - End (Hour)	% Diversity
0 - 7	20
7 - 8	30
8 - 9	40
9 - 12	50
12 - 13	40
13 - 17	50
17 - 18	40
18 - 20	30
20 - 24	20

Starting Month: January Starting Daytype: Saturday, Sunday	Ending Month: December Ending Daytype: Holiday
Period: Start – End (Hour)	% Diversity
0 - 6	20
6 - 8	30
8 -12	40
12 – 17	30
17 – 24	20

Lab Equipment Load Schedule – High use

Starting Month: January Starting Daytype: Monday	Ending Month: December Ending Daytype: Friday
Period: Start - End (Hour)	% Diversity
0 - 24	100

Starting Month: January Starting Daytype: Saturday, Sunday	Ending Month: December Ending Daytype: Holiday
Period: Start – End (Hour)	% Diversity
0 - 24	100

<u>Fume Hood Diversity Schedule</u> – Use only for laboratories that are fume hood driven. For internally load driven laboratories, no fumehood diversity schedules are necessary.

Starting Month: January Starting Daytype: Monday	Ending Month: December Ending Daytype: Friday
Period: Start – End (Hour)	% Diversity
0 - 7	53
7 - 8	55
8 - 9	60
9 - 12	98
12 - 13	73
13 - 17	98
17 - 18	65
18 - 20	55
20 - 24	53

Note: Schedule based on premise that fume hood use is directly related to occupancy of the laboratories. Using the laboratory occupancy schedule above and 100% hood airflow when in use and 50% airflow when not in use (assumes 18” operating sash height and minimum flow of 25 cfm/SF of hood work surface per NFPA 45).

Starting Month: January Starting Daytype: Saturday, Sunday	Ending Month: December Ending Daytype: Holiday
Period: Start – End (Hour)	% Diversity
0 – 7	53
7 – 9	55
9 –13	65
13 – 18	55
18 – 24	53

Note: Schedule based on premise that fume hood use is directly related to occupancy of the laboratories. Using the laboratory occupancy schedule above and 100% hood airflow when in use and 50% airflow when not in use (assumes 18” operating sash height and minimum flow of 25 cfm/SF of hood work surface per NFPA 45 – see fume hood design criteria standard).